Resonance Disorders and Velopharyngeal Dysfunction: Evaluation and Treatment
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• Author of the SNAP test for nasometry
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Seminar Outline

Resonance Disorders and Velopharyngeal Dysfunction
• Normal resonance
• Resonance disorders
• Normal velopharyngeal function
• Velopharyngeal dysfunction (VPD)
  o Velopharyngeal insufficiency (VPI)
  o Velopharyngeal incompetence (VPI)
  o Velopharyngeal mislearning
  o Effects of CLP/VPI on speech and resonance

Evaluation and Treatment
• Evaluation
  o Perceptual evaluation
  o Intra-oral evaluation
  o Instrumental evaluation
• Treatment of VPI
  o Surgical procedures
  o Prosthetic devices
• Speech therapy
• Referrals

Normal Resonance
What is resonance for speech?
• Modification of the sound that is generated from the vocal cords thru selective enhancement of frequencies
• Provides the quality of perceived sound during speech

What determines resonance for speech?
• Size and shape of the resonating cavities
  • pharyngeal cavity
  • oral cavity
  • nasal cavity
• Function of the velopharyngeal valve
Size and Shape of Cavities
- Shorter/smaller cavities: enhance higher formants
- Longer/larger cavities: enhance lower formants

Resonance is affected by the following:
- Length and volume of pharynx
- Size and shape of oral cavity
- Configuration of nasal cavity

Size and Shape of Cavities
- Differences between
  - children and adults
  - men and women
  - tall people and short people
- Makes voice quality unique to individual

Resonance and Vowels
- Vowels are “resonance sounds”
- They are produced by changing the size and shape of the oral (resonating) cavity

Resonance Disorders
- Hypernasality
- Hyponasality (denasality)
- Cul de sac resonance
- Mixed resonance

Hypernasality
- Too much sound resonating in the nasal cavity
- Usually due to VPI or fistula
- Most perceptible on vowels

Hypernasality
- Voiced oral consonants become nasalized (m/b, n/d, etc.)
  - Obligatory distortion
- Other consonants may be substituted by nasals
  - Compensatory production

Hyponasality
- Not enough nasal resonance on nasal sounds (m, n, ng)
- Due to nasal obstruction
- Nasal phonemes sound similar to oral cognates (b/m, d/n, g/ng)
- Also noticeable on vowels

Cul de Sac Resonance
- Sound resonates in a cavity (oral, pharyngeal or nasal), but cannot get out
- Due to blockage in the vocal tract

Cul de Sac Resonance
- Voice sounds muffled and low in volume
- Sound is absorbed (like a sponge) in the cavity

Cul de Sac Resonance
Types and Causes
- Oral cul de sac resonance
- Nasal cul de sac resonance
- Pharyngeal cul de sac resonance

Oral

Cul de Sac Resonance
- Sound is mostly in the oral cavity
- Due to small oral cavity size or small mouth opening (microstomia)
- Parents describe speech as “mumbling” (which is not opening the mouth very much)
Nasal Cul de Sac Resonance
• Sound is mostly in the nasal cavity
• Due to VPI and nasal obstruction from:
   – a deviated septum
   – stenotic nares
   – maxillary retraction
• Common with cleft palate and craniofacial anomalies

Pharyngeal Cul de Sac Resonance
• Sound is mostly in the pharynx
• Common in patients with very large tonsils

Pharyngeal Cul de Sac Resonance
• Has been called “potato-in-the-mouth” speech
• Enlarged tonsils are the “potatoes”

Pharyngeal Cul de Sac Resonance
• Enlarged tonsils block sound transmission to oral cavity

Mixed Resonance
• Hypernasality and/or nasal emission on oral sounds and hyponasality on nasal sounds
• Due to:
  – VPI and obstruction
  – Apraxia

Normal Velopharyngeal Function

Structures Active in VP Closure
• Velum (Soft Palate)
• Lateral Pharyngeal Walls (LPWs)
• Posterior Pharyngeal Wall (PPW)

Velum: Rest
• Moves in a superior and posterior direction
• Has a type of “knee” action
• Moves toward the posterior pharyngeal wall

Velum: During Speech

Physics and Flow
• Water (and air) flow in a forward direction until something stops it
• An obstructing object will redirect the flow

Velopharyngeal Valve and Flow
• Due to the physics of airflow, even a small opening will be symptomatic for speech.

Lateral Pharyngeal Walls (LPWs)
• Move medially to close against the velum or in some cases, behind the velum

Posterior Pharyngeal Wall (PPW)
• Has slight anterior movement toward the velum
• In some speakers, there’s a bulge called a Passavant’s ridge (formed by muscle contraction)

Passavant’s Ridge

VP Valve during Speech
• Velopharyngeal valve is closed for oral sounds
  – Most consonants (air pressure sounds)
  – All vowels (resonance sounds)
• Velopharyngeal valve is open for nasal sounds (m, n, ng)
Purpose of VP Valve
- Directs transmission of sound energy and air flow in the oral and nasal cavities during speech

Muscles of VP Closure
- Levator veli palatini (velar “sling”)
- Superior constrictor (pharyngeal ring)
- Palatopharyngeus (post. faucial pillar)
- Palatoglossus (ant. faucial pillar)
- Musculus uvulae (bulge on nasal surface)

Muscles of VP Closure

Motor Nerves of VP Function
- Glossopharyngeal (IX)
- Vagus (X)
- Accessory (XI)
- Trigeminal (V)
- Facial (VII)

Sensory Nerves of Velum
- Vagus (X)
- Glossopharyngeal (IX)

Normal VP Closure
(Nasopharyngoscopy)

Variations in VP Closure
- Coronal Pattern
  - Due mostly to velar movement
- Sagittal Pattern
  - Due mostly to LPW movement
- Circular Pattern (with and without Passavant’s ridge)
  - All structures move and close like a purse string

Patterns of Closure

Variations in VP Closure
- Non-Pneumatic:
  - gagging, vomiting, swallowing
- Pneumatic:
  - Positive (+) pressure: blowing, whistling, speech
  - Negative (-) pressure: sucking, kissing

Normal Velopharyngeal Function

Velopharyngeal Dysfunction

VPI: Velopharyngeal Insufficiency and Incompetence
- Velopharyngeal insufficiency- abnormal structure
- Velopharyngeal incompetence- abnormal neurophysiology

Velopharyngeal Insufficiency

VP Insufficiency
- History of cleft palate
- Submucous cleft palate (overt or occult)
- Short velum or deep pharynx (cranial base anomalies)
- Irregular adenoids
- Enlarged tonsils

History of Cleft Palate
- Velum may be too short following repair
- Velum may have a notch on posterior nasal surface

Submucous Cleft Palate
Nasal Surface
Deep Pharynx
• Can be due to cranial base or cervical spine anomalies (i.e., Klippel-Feil syndrome or craniosynostosis)

Adenoids
• Positioned in usual site of VP contact
• Closure is velo-adenoidal in kids
• Normal VP closure requires a tight seal
• Adenoid protrusion or indentation can affect closure

Irregular Adenoids
Enlarged Tonsils
• Can extend into pharynx, interfering with LPW and velar movement or preventing a tight VP seal

Nasopharyngoscopy of Tonsil
VP Insufficiency
Following Surgery or Treatment
• Adenoidectomy
• Maxillary advancement
• Treatment of nasopharyngeal tumors

Adenoidectomy
• Sudden increase in the nasopharyngeal dimension can cause VPI
• Often temporary and resolves within 6 weeks
• Permanent VPI is a risk, especially with history of cleft or submucous cleft

VPI Post Adenoidectomy
• Caused by a change in the structure
• Speech therapy CANNOT change structure
• Exercises don’t work because the problem is not the muscles
• VPI post-adenoidectomy requires surgical intervention by a surgeon who specializes in clefts and VPI

Le Fort I Maxillary Advancement
Maxillary Advancement
• Done surgically or through distraction
• Corrects Class III malocclusion and midface retrusion
• Improves aesthetics and articulation (obligatory distortions)
• Often done for patients with history of cleft

Pre Maxillary Advancement
Post Maxillary Advancement
• Moving maxilla forward also moves velum forward
• Velum may stretch and lengthen; LPW movement may increase
• VPI is a risk, especially in patients with history of cleft or submucous cleft

Treatment for Oral Cavity of Nasopharyngeal Tumors
• Radiation therapy shrinks abnormal and surrounding normal tissue
• Ablative surgery removes tissue
• Both increase nasopharyngeal space, making closure more difficult

Velopharyngeal Incompetence
Causes of VP Incompetence
• Cranial nerve damage
• Central neurological dysfunction
  – Injury or neuromuscular disease

Cranial Nerve Damage
• Can cause velar paralysis or paresis
• Often unilateral
• Affected side of velum droops, causing a lateral gap
• Uvula points to unaffected side
• Common in hemifacial microsomia

71 Central Neurological Dysfunction
• Injury
  – Head trauma/traumatic brain injury
  – Cerebral palsy
  – CVA/stroke
• Neuromuscular Disease
  – Myasthenia gravis, muscular dystrophy, etc.

72 Central Neurological Dysfunction
May cause:
• Hypotonia
• Dysarthria
• Apraxia of speech
• All of these can cause VP incompetence

73 Hypotonia
• Can cause poor or weak velar and pharyngeal movement
• Pharyngeal hypotonia is common with velocardiofacial syndrome

74 Dysarthria
• Affects all subsystems of speech:
  – Respiration
  – Phonation
  – Articulation
  – Velopharyngeal function

75 Characteristics of Dysarthria
• Slurred, imprecise articulation
• Poor breath support
• Decreased volume
• Slow rate
• Hypernasality- common

76 Characteristics of Dysarthria
• Poor movement of anterior structures (for articulation) and posterior structures for (VP closure)
• Weakness increases with fatigue
• Gradual onset of dysarthria with hypernasality is often the first symptom of a neuromuscular disease

77 Apraxia of Speech
• Motor speech disorder causing difficulty combining and sequencing motor movements
• Affects coordination of subsystems of speech:
  – Articulation
  – Phonation (voiced/voiceless errors)
  – Velopharyngeal function (oral/nasal errors)

78 Apraxia of Speech
• Poor coordination, timing, and duration of VP closure
• Velum goes up inappropriately for nasal sounds and down for oral sounds
• Inconsistent hypernasal/hyponasal

79 Velopharyngeal Mislearning

80 Velopharyngeal Mislearning
Causes:

- Hearing Loss/Deafness
- Secondary to VPI: Learned compensatory productions secondary to VPI
- Secondary to Mislearning: Misarticulations that cause nasal emission unrelated to a VPI

**Hearing Loss/Deafness**

- Need auditory feedback because there is no tactile-kinesthetic feedback of VP movement
- Results in a mixture of hyper- and hyponasality

**“Hypernasality” due to Misarticulations**

- Nasalization of vowels
  - Back of tongue too high on vowels
  - Can be phoneme-specific on the high vowel /i/

**“Hypernasality” due to Misarticulations**

- Substitution of nasal consonants for oral consonants (i.e., ng/l, ng/r)

**Nasal Emission due to Misarticulation**

- Due to pharyngeal or posterior nasal fricatives
- Causes phoneme-specific nasal air emission (PSNAE)
- Usually occurs on sibilants, particularly s/z
- Child is usually stimulable

**Recommendations for VP Mislearning**

- Speech therapy because this is a speech sound (articulation) disorder
- Surgery is NOT indicated!!!
- Differential diagnosis is very important!

**Effects of Cleft Palate and VPI on Speech and Resonance**

- Abnormal resonance (sound)
- Nasal air emission (airflow)
- Dysphonia (sound)

**Abnormal Resonance due to CLP**

- Hypernasality due to VPI or fistula
- Hyponasality or cul de sac resonance due to blockage

**Nasal Air Emission**

- Occurs with or without hypernasality
- Air leaks through the valve
- Occurs on high pressure consonants, particularly voiceless consonants

**Types of Nasal Emission**

- Large opening
- Small opening
  - Nasal Rustle (Turbulence)

**Nasal Emission with Large Opening**

- No impedance to airflow
- Soft, low intensity sound
- Affects articulation and utterance length

**Nasal Emission with Large Opening**

Can also cause:

- Weak or omitted consonants
- Short utterance length
- Nasal grimace
- Compensatory articulation productions

**Weak or Omitted Consonants**

- Greater the nasal air emission, the weaker the consonants will be due to loss of oral air
pressure
• Affects pressure-sensitive consonants

93 **Short Utterance Length**
• Leak of air pressure causes need to increase respiratory effort and take more frequent breaths
• Utterance length becomes shortened

94 **Nasal Grimace**
• Contraction seen at side of nose or at nasal bridge
• Overflow muscle reaction in attempt to close VP valve

95 **Compensatory Productions for Palatal Fistula**

• **Plosives (Stops)**
  • Velar plosive (backing of anterior sounds)

• **Fricatives**
  • Velar fricative

96 **Velar Fricative**

97 **Compensatory Productions for VPI**

• **Plosives (Stops)**
  • Pharyngeal plosives
  • Glottal stops

• **Fricatives**
  • Pharyngeal fricatives
  • Posterior nasal fricatives
  • Glottal fricative (/h/)
  • Nasal sniff

98 **Pharyngeal Plosive**
99 **Glottal Stop**
100 **Can be Co-Articulated**

101 **Pharyngeal Fricative**

102 **Posterior Nasal Fricative**
• Back of tongue articulates against velum
• Air pressure forced into pharynx
• VP valve opens for release of air pressure
• Causes phoneme-specific nasal air emission (PSNAE)

103 **Glottal Fricative (/h/)**
• Substituted for oral fricatives

104 **Nasal Sniff**
• Occurs as a substitution for sibilants, particularly /s/
• Usually occurs in the final word position

105 **Compensatory Productions for VPI**
• Manner of production is maintained
• Placement is in pharynx to take advantage of air flow
• VP valve will be opened during production, so there will be associated nasal emission

106 **Compensatory Productions for VPI**
• Nasal emission is due to production, so persists, even after surgery for VPI
• Speech therapy is needed postoperatively to correct placement (which will eliminate nasal emission)

107 **Nasal Emission**
with Small Opening
- Characterized by an inconsistent nasal rustle (nasal turbulence)
- Due to *bubbling of secretions* as air forced through the small opening
- Distortion is loud and distracting
- Has no effect on strength of consonants or utterance length
- Usually does not occur with hypernasality

Nasal Emission with Small Opening
- Patient can usually close with effort
- Opening increases with motoric demands and fatigue
- Can correct “in therapy” but child will not be able to maintain it
- Therefore, even a small structural gap will require surgical correction

Dysphonia
- Hoarseness
- Breathiness
- Abnormal pitch

Dysphonia
- Vocal cord nodules due to strain in the vocal tract with VPI
- Laryngeal anomalies with craniofacial syndromes
- Compensatory strategy
  - Breathiness and low volume mask hypernasality and nasal emission

Prediction of Gap Size based on perceptual features
- Hypernasality, *inaudible* nasal emission, weak consonants, short utterance length, compensatory productions
- Hypernasality, *audible* nasal emission, weak consonants, may have compensatory productions
- Possibly mild hypernasality and audible nasal emission
- Normal resonance, but inconsistent nasal rustle (turbulence)